PATENT SPECIFICATION

DRAWINGS ATTACHED

903,476

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International Classification:—H01l. B23j, k.

COMPLETE SPECIFICATION

Electrical Semiconductor Device

We, STANDARD TELEPHONES AND CABLES LIMITED, a British Company, of Connaught House, 63 Aldwych, London, W.C.2, England, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to electrical semi conductor devices and this application is an application for a Patents of Addition to British Patent No. 838,167.

According to one aspect of the present invention there is provided an electrical semiconductor device in which at least one connecting lead consists of electrically conductive flexible stranded wire, terminated at one end by a solid widening of the same material, so as to provide a flat large area contact surface and comprising a disc connecting said connecting lead to the semiconductor body, said disc being made of an electrically conductive material having substantially the same coefficient of thermal expansion as the material of said semiconductor body and a further disc made of an electrically conductive material capable of and having a thickness suitable for welding to both the first mentioned disc and said connecting lead, wherein said further disc is welded to the flat surface of said connecting lead and to said first mentioned disc.

According to another aspect of the present invention there is provided a method of treating a connecting lead to make it suitable for electrically connecting to a semiconductor device, said connecting lead consisting of electrically conductive flexible stranded wire having at one end a solid widening of the same material, said method including shaping said solid widening to a pre-determined configuration which includes a flat face having a large area contact surface, welding a disc to said face and welding a further disc to the first mentioned disc; the first mentioned disc made of an electrically conductive material capable of and having a thickness suitable for welding to both said connecting lead and said further disc, said further disc made of an electrically conductive material having substantially the same coefficient of thermal expansion as the material of the semiconductor body of said device.

The invention will now be described with reference to the accompanying drawings in which:—

Figs. 1 to 3 show, in side view, the individual manufacturing stages for a connecting lead utilised in the semi-conductor device described herein,

Fig. 4 shows, in side view, a welding tool including two discs for welding to the connecting lead also shown.

In high power rectifiers utilising semiconductor bodies, in order to reduce the likelihood of the terminals becoming detached from the semi-conductor due to thermal expansion small discs of metal have been inserted between the connecting lead and the semiconductor, which has a substantially the same coefficient of thermal expansion as the semiconductor employed. The materials as such have these coefficients of expansion as nearly as possible identical. Molybdenum has proved particularly successful for such interface layers.

There are, however, considerable difficulties in uniting the molybdenum with the metals copper or silver used as lead-in conductors. To overcome such difficulties a disc of nickel is arranged between the molybdenum disc and the connecting lead; the nickel uniting well with the molybdenum as well as with the copper or silver.

Referring now to the figures, the end of a strand 1 consisting of copper or silver, as shown by way of example in Fig. 1, is welded together to form a solid metal ball 2, as shown in Fig. 2. The ball is then pressed to take a conical shape, and at the same time welded to a nickel disc and a molybdenum disc. The finished connection is shown in Fig. 3. At its lower end the strand 1 terminates

in the solid, conical part 2a ending in a plate 2b of the same material. By means of this plate the strand is connected with the small nickel plate 3 which is joined to the molybdenum disc 4. By means of the molybdenum plate the connection so obtained is fixed to the semiconductor. This can be done, for example, by placing between the semiconductor, for example of N type silicon, and the molybdenum disc a small plate of a substance easily diffusing into the semiconductor which produces a PN junction in the semiconductor. For example, between the molybdenum disc and the silicon a small plate of aluminium can be inserted. The whole arrangement is now subjected to a heat treatment, of longer duration so that the aluminium partly diffuses into the silicon thus producing in the silicon a zone of an opposite type of conductivity. At the diffusion temperature the molybdenum disc also unites with the aluminium, so that after the diffusion process there will be an electrically good conductive contact with the zone of diffusion.

If, for example a stranded copper wire with a diameter of 1 mm is used, the solid ball will have a diameter of about 2.5 mm. The conical enlargement obtained by compressing the solid copper ball is connected with a nickel plate of a thickness of 0.2 mm and a diameter of 4 mm, to which is welded a plate of molybdenum about 0.375 mm thick and with a diameter of 6 mm.

Fig. 4 is a schematic representation of a device for producing such a connection. The device chiefly consists of the two welding electrodes 5 and 6. The upper welding electrode 5 has a suitable recess for introducing the stranded copper wire 1 which is conically enlarged in its lower portion, in accordance with the shape of the widening 2a (Fig. 3) to be produced. The plate-shaped foot 2b is produced by pressing out the material of the ball at the lower surface of the stamp 5. The movement of the upper welding electrode is limited by a stop, so that there can be no short-circuit through the two welding electrodes 5 and 6 touching each other. The strand welded to the shape of a ball is inserted into the upper electrode, as shown in Fig. 4, and clamped in a suitable way. The lower electrode 6 is provided with a recess into which the molybdenum disc 4 fits. The small nickel plate 3 is placed on this disc. The two electrodes are then pressed against each other and at the same time a current of such intensity is passed through, that the ball 2 is deformed to form the conical extension, and simultaneously all the three parts 2, 3 and 4 are welded to each other in the manner of the spot welding process.

It should also be mentioned that the thickness of the small nickel plate 3 must be dimensioned in accordance with the thickness of the lead-in conductor and, in accordance with the magnitude of the welding current. In the above described example the thickness of the small nickel plate must not fall short of 0.2 mm, since otherwise there is a risk of the nickel melting completely away in the centre and an inadequate electrical connection will result.

As already stated, silver can also be used for the connecting strand. However, the invention is in no way limited to the use of the metals mentioned or the dimensions described.

WHAT WE CLAIM IS:—

1. An electrical semiconductor device in which at least one connecting lead consists of electrically conductive flexible stranded wire, terminated at one end by a solid widening of the same material, so as to provide a flat large area contact surface and comprising a disc connecting said connecting lead to the semiconductor body, said disc being made of an electrically conductive material having substantially the same coefficient of thermal expansion as the material of said semiconductor body and a further disc made of an electrically conductive material capable of and having a thickness suitable for welding to both the first mentioned disc and said connecting lead, wherein said further disc is welded to the flat surface of said connecting lead and to said first mentioned disc.

2. A device as claimed in claim 1 in which said first mentioned disc is made of molybdenum.

3. A device as claimed in claim 1 or 2 in which the connecting lead is made of copper and said further disc is made of nickel.

4. A method of treating a connecting lead to make it suitable for electrically connecting to a semi-conductor device, said connecting lead consisting initially of electrically conductive flexible stranded wire having at one end a solid widening of the same material, said method including shaping said solid widening to a predetermined configuration which includes a flat face having a large area contact surface, welding a disc to said face and welding a further disc to the first mentioned disc; the first mentioned disc made of an electrically conductive material capable of and having a thickness suitable for welding to both said connecting lead and said further disc, said further disc made of an electrically conductive material having substantially the same coefficient of thermal expansion as the material of the semi-conductor body of said device.

5. An electrical semiconductor device substantially as herein described with reference to Figs. 1, 2 and 3 of the accompanying drawings.

6. A method of treating a connecting lead to make it suitable for electrically connecting to a semiconductor device substantially as herein described with reference to Fig. 4 of the accompanying drawings.

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903,476 COMPLETE SPECIFICATION
1 SHEET

FIG.1.

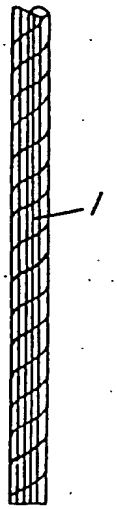

FIG.2.

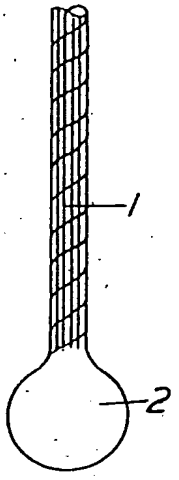

FIG.3.

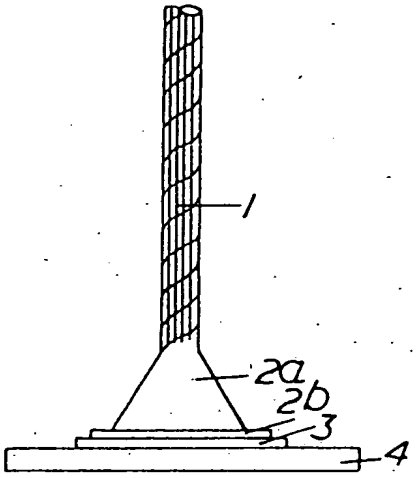

FIG.4.